The Benefits of Student Research in Information Systems Security Education

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1 Introduction

At a small public school in a New York City suburb, Mary Demerec taught science to kindergarten through eighth grade students. It was a remarkable set of classes. Mrs. Demerec was among the first women, if not the first woman, to receive a degree in Electrical Engineering from Cornell University. For personal reasons, she chose a life of teaching and her many students benefitted from that choice.

Mrs. Demerec's classroom was like no other. Housed in the old cafeteria in the school basement, it had been converted into a science wonderland. Science was eagerly anticipated by all of her students. Although I remember being issued a science textbook and flipping through it, the book and lectures weren't part of the class. Instead, we "experimented." Our "experiments" were trivial for the younger students. For example, in fourth grade I painted some cardboard boxes to look like houses and electrified my little town. Everything was crude and homemade. Small blocks of wood onto which strips of metal were attached with nails served as our breadboards. Holes in the metal were sockets for flashlight-size bulbs. Some of the metal strips could be touched together to form switches. Wires were strung up to batteries. At the age of eight, I learned the difference between series and parallel circuits and how to hook them up.

No one else had a project like mine. Mrs. Demerec, helped each child pick an experiment that best fit his or her capabilities and inclinations. A boy in my class had a project that involved a lot of hammering. He was active and not very studious. He may not have learned the same material as I, but both of us loved Science and wanted to be there.

Occasionally there was a demonstration, usually performed on something from the fish market or the butcher shop: fish eyes and brains; cow eyes and brains; meatless lamb legs and shoulders. These too were memorable events, but not the heart of the learning experience.

Our grade-school science program was "research for children." It exemplified the Socratic method in the extreme. We were excited about learning and were learning to think for ourselves.

Today we are all taking our first few steps in a new world. One in which information technology will transform practically every aspect of our lives. We as individuals, small businesses, corporations, and nations cannot accomplish our work using computers without computer security. For this reason, we need computer security education programs, but more importantly, we need people to help us build this new

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world. We need to produce graduates who are enthusiastic and creative. Research is one of the best ways to achieve this objective.

2 Creating the Future

To understand the applicability of research to information systems security education the notion of research must be defined and interpreted in the context of this field.

A dictionary definition [1] of research is

> Studious inquiry or examination; *esp:* investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws.

Obviously, in computer science and computer engineering, researchers are not in the business of discovering new laws of nature. Instead we rely upon a mathematical foundation built upon certain axioms as a basis for research in two principal areas. The first is theory, or the extension of the mathematical foundation. The second is to translate that mathematical foundation to the tangible world through the application of technology. We construct abstract models of how systems should operate and then create technical models, specifications, designs, and implementations of experimental systems. Experiments are performed on those systems which may force us to pursue additional mathematical extensions of our theory, create new models, and continue the cycle. These discoveries permit us to articulate principles for building systems of computers. Those principles become the cornerstone for advances in engineering and technology.

To apply this recurring cycle of theory, model, and experiment to computer security, we need only narrow the field of discourse. Security research attempts to satisfy certain requirements, usually articulated in terms of policy related to the confidentiality, integrity, and availability of information resources, on complex man-made systems.

What is important to realize is that computer security research, like all other research, is experimental in nature. This means that sometimes things don't work the way we may have hoped they would. However, negative results are not necessarily bad results. They can lead to new insights and new developments. That is why we call it research.

Research has a "blue-sky" quality that allows us to not only consider current technology but to create the future. It is a highly creative process. The creative thinker has time to ponder. Throughout his career, the late Richard Hamming set aside most of each Friday to "think great thoughts." New ideas result from having the luxury of expansive thinking that a good research program can provide.

3 Educational Benefits of INFOSEC Research

The integration of research into a program of computer security education benefits not only students, but their teachers, and, ultimately, the institutions and enterprises that will hire the graduates of these pedagogical programs.

3.1 Enthusiasm

Computer Security is an exciting field. It is possible to stimulate student vicariously with tales of others' computer security exploits and adventures, but from my observations it appears that being involved in the exploration oneself is even more engaging. The adventure of exploring the unknown raises the level of enthusiasm by at least an order of magnitude.

3.2 Preparation

It is difficult to extend the boundaries of knowledge if you do not understand that which is known. To do this, underlying principles and facts must be internalized so that they can be creatively applied in a new context. Despite the best lecture and laboratory materials, a problem often does not become *real* until the student has had to grapple with it alone.

3.3 Creative learning

Some may argue that interactive, computer-based learning programs are active learning, but is this really so? Even multimedia, web-based activities are generally passive and tethered to the instructor. Yes, the student is *actively* selecting from drop-down menus and typing, but in many cases the clever, and not-so-clever, student can guess what the instructor wants; it easily becomes rote learning.

In contrast, research cannot be passive. It demands active involvement and creativity. The teacher can act as a guide, helping students avoid blind alleys and pitfalls, but the students must do the work. Involvement is complete. Students lie awake at night pondering research problems.

Even when the instructional program has been very thorough, a research topic will require understanding additional background material. The student will conduct a survey of the research area and become an expert on the topic at hand. In addition, research often involves cross fertilization.

Computer systems are tremendously complex and students learn this. They learn that although an individual may create a fabulous application it must work in a networked world and will depend upon other components of the system. Since security must be built into systems, be they single computers or large-scale networks, students must often engage in some level of systems engineering. They must consider how all of the various components will connect and work together. Security mechanisms result from the desire to control who has access to portions of an enterprise's work, which includes programs as well as data. Students must consider how security policy enforcement will interact with other system requirements. Concepts from many areas of computer science or even from other fields may be applicable to the research problem. As the student explores new areas, and talks to a broad research community, cross-fertilization takes place and new ideas may emerge.

As students, we learn about the scientific method. We learn of Aristotelians who *thought* about how the world was and the Renaissance experimentalists who actually took a look and *found* out. Galileo's notion of conducting an experiment is memorized and recited: Problem, Hypothesis, Procedure, Data, and Conclusions. To conduct research, one must apply these principles and create a method for attacking the problem at hand. Thus students learn not only the scientific method, but project organization.

Students conducting research can engage in discourse with those in academe and industry. Most computer security research is of interest to someone beyond the hallowed halls of one's institution. For example, the computer security research of the Naval Postgraduate School Center for Information Systems

Security Studies and Research (NPS CISR) [2] has involved the interest of, and often collateral participation by, researchers and developers from the military services and Department of Defense (DoD) activities, the U.S. Government, federally funded research and development centers (FFRDCs), other academic institutions, and numerous hardware and software vendors.

By presenting their results at conferences or in papers, and in theses and dissertations, students are able to distill their work and share it with a broad community.

Completion of a research project teaches the student that he or she is capable of extending that which is known. Ordinarily, we fear the unknown, but by having learned a method for probing and pushing back the limits of knowledge we can view the unknown as a challenge that can be overcome a little bit at a time. This provides graduates with the confidence to pursue new ideas throughout their careers.

3.4 Beyond Students

Students are not the only ones who benefit from research-based education programs. Professors and teachers benefit by helping students chose topics that will further their overall research objectives. They create the team that works together to solve specific research problems. Students learn how to be team players yet retain their individuality. Good academic research groups produce graduates who know how to work in a team to build upon each other's accomplishments.

For teachers, pursuit of research gives us a depth of understanding that cannot be developed through reading textbooks and magazine articles. We must understand the subject inside out. We must attend conferences and read proceedings, journals and seminal papers. The depth of understanding that results will be reflected in our classroom instruction. We know about the exciting places the topics in the lecture notes can lead.

Our research keeps us current. We are enthusiastic about solving a problem and convey that enthusiasm not only to the students with whom we are conducting research, but to the many students in our classes for whom computer security will not be a career objective.

Through research on critical problems in computer security, academic programs create ways to provide better system security where it was previously inadequate or absent. For science and industry, research-based educational programs not only produce students who know how to learn for themselves and think creatively, these groups solve problems and push the envelope of our understanding of how systems can be constructed and used.

4 Summary

In ten to fifteen years, computers will be even more ubiquitous than they are today. Computer security will remain an important hidden factor in maintaining personal privacy, enterprise competitiveness, and national security. Academe will need new teachers to conduct research and lead students into the unknown. Industry will need individuals who can address enterprise-level information systems security problems. Research-based academic efforts foster the atmosphere in which we can nurture those individuals who will create the future.

References

[1] *Webster's Ninth New Collegiate Dictionary*. Merriam-Webster, Inc, Springfield, MA, 1986.

[2] Cynthia E. Irvine, Daniel F. Warren, and Paul C. Clark. The NPS CISR Graduate Program in INFOSEC: Six Years of Experience. In *Proceedings of the 20th National Information Systems Security Conference*, pages 22–30, Baltimore, MD, October 1997.